Full Length Research Paper
Solid Waste Management with Special Reference to Allahabad City

Kalpana Devi[1] and Prof. Kiran Singh[2]
[1]-*Research Scholar, Department of Economics, University of Allahabad, Prayagraj, Uttar Pradesh, India.*
[2]- *Head of the Department, Department of Economics, University of Allahabad, Prayagraj, Uttar Pradesh, India.*

ARTICLE DETAILS	ABSTRACT
Corresponding Author: Kalpana Devi *Key words:* Solid Waste Management, Allahabad City & Allahabad Municipal Corporation.	Solid waste Management is an important issue for the Allahabad city. Allahabad Municipal Corporation is responsible for the management of the MSW generated in the city. The entire operation of solid waste management system is performed under four heads, namely, cleaning, collection, transportation and disposal. In Allahabad District, near about 500 TPD waste is generated. Every year Allahabad Municipal corporation spends on average 22% of its total budget on solid waste management respectively. Government tries to make clean & green city of it. Therefore they implement a policy for it to convert this city as **Smart City.** After studying all the parts of solid waste management of Allahabad Municipal Corporations we are concluding that the dumping ground is inadequate to dump or landfill the waste. Most of the time, the processing units are not in working condition. Due to this the local people who are living near the dumping ground of Baswar are facing health related problems. The Municipal Corporation should think on this and find some new place for the dumping ground as this place comes in the city area. Most of the employees are on contract basis in the Solid Waste Department. Some societies are trying to reduce the waste in their places. But such society is not being motivated by the Municipal Corporation to reduce or recycle the waste from their society.

1. Introduction
Solid waste Management is an important issue for the Allahabad city. Allahabad Municipal Corporation is responsible for the management of the MSW generated in the city. The entire operation of solid waste management system is performed under four heads, namely, cleaning, collection, transportation and disposal. It has a population of 49.36 lakh and is densely populated with 911 persons per sq. km. 75% population lives in Rural area. Therefore it shows that rural population is greater than urban population in Allahabad District while literacy rate is higher in urban area. 68% literacy rate is found in this area. In Allahabad District, near about 500 TPD waste is generated.

In the city area of about 63 km2, the cleaning and collection operations are performed by the public health wing of AMC; while transportation and disposal of MSW are being performed by the transportation wing of AMC. It is dumped into depots (49 depots). MSW is then loaded into the transportation vehicles, which transport the waste to different disposal sites. Every year Allahabad Municipal corporation spends on average 22% of its total budget on solid waste management respectively. Government tries to make clean & green city of it. Therefore they implement a policy for it to convert this city as **Smart City.**

2. Literature Review
Jamal Mohammad Salih Irhoha, V. C. Agarwalab, Deepak Lalak, Mukesh Kumar (2014) said that city waste management is a global environmental problem in today's world. Due to population growth, there has been an increase in

commercial, residential and infrastructure development and this has a negative impact on the environment. Urban solid waste management is considered one of the most serious environmental problems facing municipal authorities in developing countries. One of these impacts is due to the location of dumping sites in unsuitable areas. This paper deals with the determination of suitable sites for disposal of waste generated from the surrounding areas of Allahabad city using GIS techniques. Remote sensing and geographic information analysis were used in this study to locate a suitable site for waste disposal. Land use land cover mapping, geology mapping, geomorphological mapping, lithology mapping, slope mapping, road and rail network, and drainage mapping were used for on screen visual interpretation of Landsat data 2011. All classes are given attributes. After attribution the data base map was created and after various thematic maps like geomorphology, lithology, drainage, slope, streams, population and road maps were created and weightage was allotted to them on the basis of key parameters. All thematic vector layers were integrated and introduced into the overlaying and weighting analysis to carry out the site suitability index (SSI). Waste disposal targets potential sites using the Spatial Analyst tool in Arc GIS 9.3. The potential site for waste disposal has been analyzed by the following analysis of geospatial data using computerized GIS software; The selection of sites for waste disposal was based on various criteria, such as landuse, landcover, geology, lithology, DEM, infrastructure. The ranking (order of priority) was done on the basis of knowledge of the study area to select the best sites for waste disposal. The result generated through GIS analysis shows that 0.98 km2 area is highly suitable, 3.43 km2 area is moderately suitable, 464.01 km2 area is less suitable, 291 km2 area is not suitable and 186.16 km2 unspecified for waste disposal. Is. The studies show the importance of RS and GIS technology in present days.

Vijay Krishna and Sadhna Chaurasia (2017) stated that as economic development takes place in the country, the generation of municipal solid waste also increases. Not only is this but the characteristics of municipal solid waste also vary. This research has been done to evaluate the status of municipal solid waste of Allahabad city. A questionnaire has been designed to find out the general perception of the citizen of Allahabad city about various aspects of municipal solid waste and its consequences and management. The questioner has questions related to types, sources, methods of collection, storage, transportation, etc. of municipal waste generated in the city of Allahabad. At the end of this questionnaire, suggestions have also been given to the citizens for better management of solid waste.

Akhilesh Kumar, Avalokita Agrawal (2020) stated that in recent years, exponential population growth, high density of urban areas, diverse culture, changing food habits, and lifestyles have changed the context of Municipal Solid Waste Management (MSWM) in India. I have seen an unsolved problem. As a result, the municipality is facing several other issues related to the collection, treatment and management of solid waste. The present study is a comprehensive review summarizing the current SWM status, identifying the associated challenges and deriving possible solutions for MSWM in the Indian context. As discussed in this review article, there is an urgent need to adopt adequate treatment and recycling strategies as per the Indian solid waste composition. Appropriate implications of possible solutions for MSW at centralized and decentralized level need to be emphasized through various available scientific treatment procedures. Hence there is a need to focus on creating potential opportunities to private agencies, with the participation of municipal, informal sectors and achieve the long term goal of MSWM sustainability for Indian cities.

Renu Hujare and Kashinath Telsang (2020) focused that the availability and reliability of waste generation data is a denied problem in a developing country like India. Inconsistencies in waste generation data are confirmed by comparing cities and states with national-level data. It is found that the data for cities and urban India closely match each other, which is not the case between urban India and states. About 22% of the studied literature documents depend on the limited data generated by CPCB and NEERI. Incorrect population data is considered to miscalculate the waste volume. This causes a wide range of percentage variability and large values of standard deviation indicating inefficiencies in data collection. The literature review explores the current challenges in maintaining reliable waste generation data. The study has recommended involvement of academic and research institutions in handling the waste management database in collaboration with the government. In addition, the study suggests various technological and policy changes for better waste management.

3. Objectives
The main objectives of this study are as follows:-
- To highlights the types, quantity and collection method of solid waste generation in Allahabad city.
- To assess the growth rate of solid waste in Allahabad city.
- To give reason for increasing solid waste management system of the study area.

4. Hypotheses
H0: Growth rate of solid waste is not statistically change during last decades in Allahabad city.
H1: Growth rate of solid waste is statistically changed during last decades in Allahabad city.

5. Research Design
Explanatory Research Method is used in this study. Allahabad city of Uttar Pradesh is purposively selected as the study area. The study is conducted on the basis of both Primary and secondary data. The Secondary source of information will

be collected from Nagar Nigam Allahabad SLB 2013, SWM DPR 2007 and Integrated Solid Waste Management Project at Allahabad, CDM Executive Board, Uttar Pradesh. Allahabad municipality has 8 zones and 100 wards from which the researcher will randomly select 11 wards from the city. The primary data will be obtained from the 25 respondents in Allahabad city with the help of interview schedule using purposively sampling method in which 2 sanitary workers (collectors) from Nagar Nigam office from each ward and 3 officers is selected purposively from Baswar Office (Solid waste Collectors and converters).

6. Analysis for solid waste management in Allahabad City
6.1 Collection-Types and Quantity of Solid waste
Table 1 shows that 46% solid waste generates from household sector and 41% solid waste generates from construction, Debris, horticulture and etc. Only 1% - 1% solid waste generates from Hotels & Restaurants and Commercial establishments.

TABLE-1: generation of municipal solid waste –allahabad city

Source of solid waste	Solid waste generated (TPD)
Households	(46%)
Hotels and Restaurants	(1%)
Street Sweepings	(5%)
Markets (vegetable markets, mandis etc.)	(6%)
Commercial Establishments (Institutions etc.)	(1%)
Other Sources (Construction Debris, Horticulture Waste etc.)	(41%)
Total	**100%**

Source: Nagar Nigam Allahabad, 2018

The practice of throwing the wastes into the streets and drains is more prevalent in case of many households in the city as well as within the community of small restaurants and eateries; this unhygienic practice has resulted in clogging of drains. Excessive polythene has also emerged out to be one of the reasons for frequent clogging of drains. Solid waste is collected in handcarts by the operator and is disposed off to near by secondary collection point. However, others throw the household waste outside their residences from where sweepers of NNA collect waste by means of rickshaw trolley and dump the same into the dustbins or onto streets (open dump). In some of the cases, generators themselves dispose off waste in nearby waste collection points/ containers, onto the streets, or in the nearby drains.[2]

The safai karamcharis employed by the NNA do street sweeping, collect drain silt and waste heaps from roadsides and dispose them off at a nearby open dumps. These unorganized disposal methods have resulted in accumulation of solid waste on roadsides and vacant plots and in low lying areas and storm water drains.[3]

Table 2 shows that Total waste has been increasing continuously. It has been 1.5 times increased in 2022 than 2011. It will reach at 2.5 times at 2030, of it increases at the same rate. Annually percentage rate of change is averagely 3.68% in first decade (2011-2020). It is also shown in the table 4.2 that at the same rate of increases, the annually percentage rate of change will be reached at 4.29% in 2030 as a compare to 4% in 2011. It means average AGR will near about 3.96% in two decades that has 3.68% in first decade. While it will 4.24% in second decade. Therefore average AGR of second decade will be more than first decade.

Types of waste is mostly waste for composting, construction and demolition, inerts, waste for RDF, glass, plastic and metal in rates of total. GR of C & D is 55.7% during 2011 to 2012 while GR of waste of C is 55.9% in the same period. R of other each waste is also same. In 2030, it will be at 117.35%, 117.54% respectively. Resultant it can be said that solid waste will be more than double during two decade.

Table 2: Waste composition of allahabad city (in **TPD**)

Year	Total Waste (TPD)	Construction and Demoloition Waste (TPD)	Total waste without C&D waste (TPD)	Waste for composting (TPD)	Waste for RDF (TPD)	Glass (TPD)	Plastic (TPD)	Metal (TPD)	Inerts (TPD)	Change in waste quantity annually (TPD)	%age change in waste quantity annually
2011	699.74	121.62	578.12	456	45	7	5	1	64		
2012	727.7	126.48	601.22	475	47	7	5	1	67	27.96	4.00%
2013	756.97	131.56	625.41	494	48	8	5	1	69	29.27	4.02%

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[2] SWM DPR 2007 by M/s Tetra Tech

[3] SWM DPR 2007 prepared by M/s Tetra Tech

2014	787.61	136.89	650.72	514	50	8	5	1	72	30.64	4.05%
2015	819.67	142.46	677.21	535	52	8	5	1	75	32.06	4.07%
2016	853.21	148.29	704.92	557	55	8	6	1	78	33.54	4.09%
2017	888.32	154.39	733.93	579	57	9	6	1	81	35.11	4.12%
2018	925.05	160.77	764.28	603	59	9	6	2	85	36.73	4.13%
2019	963.47	167.45	796.02	628	62	10	6	2	88	38.42	4.15%
2020	1003.67	174.44	829.23	655	64	10	7	2	92	40.20	4.17%
2021	1045.71	181.74	863.97	682	67	10	7	2	96	42.04	4.19%
2022	1089.67	189.38	900.29	711	70	11	7	2	100	43.96	4.20%
2023	1135.64	197.37	938.27	741	73	11	8	2	104	45.97	4.22%
2024	1183.69	205.73	977.96	772	76	12	8	2	109	48.05	4.23%
2025	1233.92	214.46	1019.46	805	79	12	8	2	113	50.23	4.24%
2026	1286.42	223.58	1062.84	839	82	13	9	2	118	52.50	4.25%
2027	1341.27	233.11	1108.16	875	86	13	9	2	123	54.85	4.26%
2028	1398.58	243.07	1155.51	912	90	14	9	2	128	57.31	4.27%
2029	1458.45	253.48	1204.97	951	93	14	10	2	134	59.87	4.28%
2030	1520.96	264.34	1256.62	992	97	15	10	3	139	62.51	4.29%

Source: Integrated Solid Waste Management Project at Allahabad (2022), CDM Executive Board, Uttar Pradesh Version 03. Coloured value is estimated values

Waste Composition of Allahabad City in MT/year has been sea in Table 3. Table shows that highest percentage in bio-degradable total waste for composing is food, food waste beverages and tobacco during 2011 to 2022. Textiles have second position during the same time period. Garden yard and park wastes have third position in the same period. Wood and Wood products has lowest percentage in total waste.

Table-3: Waste Composition of Allahabad **City (in MT/year)**

Year	Total waste without C&D waste (in MT/Year)	Bio degradable waste for composing (in MT/Year)	Food, food wastes, beverages and tobacco (in MT/Year)	Wood and wood products (in MT/Year)	Pulp, paper and card board (in MT/Year)	Textiles (in MT/Year)	Garden yard and park wastes (in MT/Year)
2011	211014	166595	145177	3587	4537	8230	5064
2012	219445	173252	150978	3731	4718	8558	5267
2013	228275	180223	157053	3881	4908	8903	5479
2014	237513	187516	163409	4038	5107	9263	5700
2015	247182	195150	170061	4202	5314	9640	5932
2016	257296	203135	177020	4374	5532	10035	6175
2017	267884	211495	184305	4554	5760	10447	6429
2018	278963	220241	191926	4742	5998	10880	6695
2019	290547	229387	199897	4939	6247	11331	6973
2020	302669	238957	208236	5145	6507	11804	7264
2021	315349	248968	216960	5361	6780	12299	7568
2022	328606	259434	226081	5586	7065	12816	7887

Source: Integrated Solid Waste Management Project at Allahabad (2022), CDM Executive Board, Uttar Pradesh Version 03.

H0: Growth rate of solid waste is not statistically change during last decades in   Allahabad   city.
H1: Growth rate of solid waste is statistically changed during last decades in Allahabad city.

Semi Log is taken for calculating growth rate of solid waste of Allahabad City. Estimated regression is as follows-

$$lnSW_t^{AC} = -68.75 + 0.04T + u_t$$

The growth rate of solid waste is 0.04 or 4% in Allahabad City during the year from 2011 to 2022. Statistical results are shown in the Table-5.1.

Table-4: Results of coefficient and related test at allahabad ciy

Variable	Coefficient	S.E	t-Statistic	P Value	R^2	F-Statistic	P Value
T	0.04	9.66E-05	417.02	0.00	0.99	173907.7	0.00
Intercept	-68.75	0.195	-352.96	0.0000			

Source: Calculated by researcher

Coefficients and their t test results, R^2, f test (for goodness of fit) results shows that all are significant at 5% level of significance and 12 degree of freedom. The homoscedasticity is found in residuals and there is no correlation present in the residuals. Normality is tested through Jarque Bera test, serial correlation is tested Breusch-Godfrey LM test and Homoscedasticity is tested through Glejser test.

The value of R^2 is 0.99, which show that independent variable cause 99% variation in the dependent variable .The value of F-statistic is of the degree of freedom (1, 11) and 5% level of significance, is found 173907.7 and its probability is 0.00 (less than .05), which represent that model belongs to goodness of fit. The result shows that the growth rate of solid waste is equal to 4% at Allahabad City.

***Thus the Null Hypothesis will not be accepted and Alternative Hypothesis will be accepted that is* Growth rate of solid waste is statistically not stagnant during last decades in Allahabad city.**

6.2 Reason for increasing solid waste in Allahabad city

The reasons of increasing municipal solid waste in Allahabad City are-
- **Social Factors**
✓ Due to change the life style of citizen in Allahabad City, They prefer varieties in each product. Therefore, sachets are available in the market. Wrapping paper or material is a solid waste substance after using the products.
✓ Due to change the consumption pattern of citizen in Allahabad City, They prefer packed food or quick food like chips, soft drinks etc. that are available in the market. Therefore, they purchase it mostly daily. Packing material is just used for providing safety of the product. After using product, packing converts into solid waste.
✓ Neither good quality of textile is provided by producers nor customer like to mend of torn clothes themselves. It becomes solid waste in very short period.
✓ Public does not like to reuse the product in their household to maintain status in the society. They feel that it is a solid waste. On the other reuse has been done by private agencies that are working in this field in Allahabad City.
✓ High corruption and inflation, insecurity is increasing in the Allahabad City, therefore security products demand has been increasing in the Allahabad City like camera, digital locks etc. After sometimes it converts into solid waste.

- **Economic Factors**
✓ Increasing demand for cheap products, producer innovate these types of items and provides cheap quality products to the customers that are just use and throw products. It converts into solid waste in a very period. It increases producer market in one hand as well as generates low quality product in other hand. Therefore, whatever products producer provides to the customer, customer purchase and use it. Quality has been degrading of durable goods, textiles etc. So, solid waste has been increasing.
✓ Life becomes like a show off theater where producer sale and customer purchase stylish electronic and mechanical gadgets. To maintain their status, Chinese product demand that are highly 'one time use product' is high in Allahabad City. Therefore solid waste has been increasing.
✓ These types of products generate waste in the market as well as inflation because increasing demand with low innovations restricts supply in the given period. On the other hand maintenance of the solid waste (that is only invested by public sector) also the cause of the cost inflation due to increases tax burden.

- **Marketing factors**
✓ Use and throw packaging material is used that becomes solid waste after torn and opening the product. It cannot use further.
✓ Quality of packing material is also very bad. Therefore, it cannot reuse for other work like water bottle plastics.
✓ Attractive advertisement persuades the customer to use products that available in the market.

- **Government Policy Factors**
✓ In education system, convent books and uniforms are replaces in each year. It is major cause of increasing the solid waste of paper and textiles in Allahabad City.

✓ Lack of implementation of rules strictly in the area is also a cause of increasing solid waste in Allahabad City.
It can be summarised and converted into demand and supply factors. Chart 1 & 2 shows the demand and supply side of increasing solid waste in Allahabad City.

Chart 2

Source: Created by Researcher

6.3 Collection Management

The slaughter house in Allahabad is situated at Atala is an open slaughter house and almost 100 year old. There is no systematic arrangement of cleaning/maintenance. The waste is dumped in the open; Nagar Nigam Allahabad is entitled with the management of this slaughter house. There is no detail record maintained and available with Nagar Nigam Allahabad for quantity of waste generated from slaughter house. Segregation of waste at source is very minimal i.e. 3.7% (Source: Allahabad SLB 2013) practiced in Allahabad city as per the records of NNA. As per the secondary survey, there are no transfer stations also in Allahabad city wherein waste is segregated before dumping at the final disposal site.

Secondary collection process is streamlined in the city of Allahabad to an average level. As per the SWM DPR 2007 prepared by M/s Tetra Tech, the MSW collected from each of the primary collection points mentioned above is transported to designated open dump areas and DP containers (mostly on the main roads), which are the secondary collection points identified in Allahabad which are nearly 50 in number and about 160 Dust bins spread over all 80 wards of the city.
The waste collection from the secondary collection points starts by Dumpers and Tractor trolleys from 8 A.M and goes on till 5 PM in the evening. These vehicles transfer the MSW to trenching grounds/ crude dumping sites namely Buxi Band and Kareli area. (near Yamuna River).

NNA has 85 transportation equipment / vehicles. Table 4 gives information about the number of vehicles used in collection and transportation of solid waste in the city. 380 MT/Day out of the total generated waste of 540 MT/ Day of waste in the city is collected and transported to the final disposal site.

Table-4: Details of secondary waste collection

Vehicle category	Number of vehicles	Capacity of each vehicle (mt)
Ashok Leyland – 110 HP	4	4.5
TATA – 1613 – 135 HP	3	4.5
Swaraj Majda – 80 HP	8	3.0
TATA – 709 – 80 HP	11	3.0
TATA – 207 – 65 HP	2	2.5
JCBs 9	9	
RCs – 135 HP	6	
Tractor Trolleys	8	2.0
Three Wheelers	32	0.5
Loaders – 48 HP	2	
Total no. Of equipments/ vehicles	85	

Source: Nagar Nigam Allahabad, 2018

The waste transportation vehicles are operated, supervised and maintained at workshop located in front of railway station (south side). The workshop is supervised by workshop in charge. At present this responsibility is given to Junior Engineer. The existing dump sites/trenching grounds namely, Buxi Band and Kareli, are located at an average distance of 10 km, from the city centre. The transportation vehicles make three to four trips per day to transport the MSW to these dumping sites. It takes about 1.5 to 2.0 hours to make a trip depending on the traffic conditions. The waste is transported in open vehicles and this creates unhygienic conditions in the city.

It has been reported that the existing human resource strength has been nearly commensurate to the desired strength of all the positions essential in the department, with the exception of safai karamcharis/maistries. As can been seen fromTable-5, the difference of filled and sanctions positions is minimal for each category of the post; however, there is a reported deficiency of 620 safai karamcharis against the requirement of 1400 safai karmacharis translating to a 44% deficit. It has also been reported that the senior management positions are filled as per the requirement which enables continuous administration and service delivery management. However, as observed in the other sectors, SWM sector has also witnessed an urgent need for capacity enhancement strategy formulation and its implementation for the existing staff in order to handle the responsibilities of their roles and dispense their duties per the mandate.

Table-5: Human resource strength in SWM sector

Staff post	Sanctioned post	Filled Post	Vacant Post
Sanitary Supervisor	151	111	40
Naistries/Safai Karamchari	2575	2048	527
Cleaners/drivers	68	58	10
Labourers	10	10	0

Sources: Nagar Nigam Allahabad, 2018

Total 16305 MT/month solid wastes is being generated in the city and waste received at disposal point is 3650 MT/month whereas waste received at processing and recycling facilities is 10250 MT/month. After waste rejected (2700 MT) at processing facilities total waste processed is 7635 MT/month and waste disposed in open dump site is 3650 MT/month. Allahabad city have an engineered scientific treatment and disposal mechanism under process in place. User Charges demand per year is 281.35 lakhs and User charges collected per year is 31.1lakhs (11.5% of collection efficiency).

7. Conclusion

After studying all the parts of solid waste management of Allahabad Municipal Corporations we are concluding that Allahabad Municipal Corporations are doing their activity at their best level but till then they are lagging behind in any way to lift 1135.64 Tons of waste per day. They do not have that capacity or equipment to handle such amount of daily waste. NGOs are helping them to collect the waste as well as reduce the waste. Now the dumping ground is inadequate to dump or landfill the waste. Most of the time, the processing units are not in working condition. So without any processing they are dumping the garbage at the dumping ground. Due to this the local people who are living near the dumping ground of Baswar are facing health related problems. The Municipal Corporation should think on this and find some new place for the dumping ground as this place comes in the city area. Most of the employees are on contract basis in the Solid Waste Department. These people are not taking care of the waste while collecting the waste as well as handling the waste. So sometimes we can see that after the collection of garbage from the bins by the dumper, there is a pile of garbage spread on the road. The transport system of Allahabad Municipal Corporation lags behind due to unknown in any way; any new technology is applied on it. The authorities cannot track the vehicle due to non-implementation of GPS system or implementation of this system but not in working condition. There is no modern technology like RFID (Radio Frequency Identification) in coaches or transport vehicles. The awareness program run by the Allahabad Municipal Corporation is not

enough to change the mind of the people of Allahabad so that they know all the rules and regulation of solid management and they will not throw the garbage on the side of the road. Some societies are trying to reduce the waste in their places. But such society is not being motivated by the Municipal Corporation to reduce or recycle the waste from their society.

8. References

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